Reports of Investigation

ACC/AHA guidelines as predictors of postoperative cardiac outcomes

Mohamed J. Ali MD FRCPC,*
Patrick Davison MD,†
William Pickett PhD,‡
Naheed S. Ali MD FRCPC§

Purpose: Recently, the American College of Cardiology - American Heart Association (ACC-AHA) published guidelines and an associated algorithm for preoperative cardiovascular evaluation of patients undergoing non-cardiac surgery. Our purpose was to (i) test guideline's ability to predict adverse cardiac events within seven days after surgery, (ii) determine whether medical clinical predictors or surgical risks was a better predictor of cardiac events.

Methods: Retrospective review of 119 cardiology and anesthesia consultations over 15 mo, ending March 31, 1998. Patients were classified into their respective medical clinical predictor and surgical risk groups, as outlined in ACC-AHA guidelines. Associations between the medical predictor and surgical risk scores and adverse cardiac outcomes were quantified via multiple logistic regression analysis. Two outcomes were employed. Outcome 1, included: myocardial infarction/ischemia; angina; congestive heart failure, arrhythmia or death. Outcome 2 expanded the definition to include "cancellation of surgery due to cardiac risk" as a negative cardiac outcome.

Results: Diabetes, Canadian Cardiovascular Class (CCS) III or IV angina, and MI within six months before surgery were strongly associated with the two cardiac outcomes. For outcome 1 and 2, medical predictors and surgical risks, considered simultaneously, performed with a sensitivity of 93% and specificity of 46-51%. When considered separately, major clinical medical predictors had a sensitivity of 87-89%, while surgical risks showed a specificity of 89% in predicting the two outcomes.

Conclusion: Medical predictors in ACC-AHA classification scheme were highly sensitive whereas surgical risks were more specific in predicting adverse post-operative cardiac events. Prospective study is needed to confirm these observations.

Objectif : Récemment, l'American College of Cardiology - American Heart Association (ACC-AHA) a publié des recommandations, et un algorithme qui leur est associé, pour l'évaluation cardiovasculaire préopératoire des patients qui doivent subir une intervention chirurgicale non cardiaque. Notre objectif était de (i) tester la capacité des recommandations à prédire les complications cardiaques qui pourraient se produire dans les sept jours suivant l'opération, (ii) déterminer si ce sont les facteurs prédictifs médicaux cliniques ou les risques chirurgicaux qui peuvent le mieux prédire les complications cardiaques.

Méthode : On a procédé à une revue rétrospective de 119 consultations en cardiologie et en anesthésie des 15 mois précédant le 31 mars 1998. Les patients ont été répartis en divers groupes selon leur facteur prédictif médical clinique respectif et les risques chirurgicaux liés à leur condition, comme l'indiquent les recommandation ACC-AHA. Les associations entre les facteurs prédictifs médicaux et les scores de risques chirurgicaux et les complications cardiaques ont été quantifiées au moyen d'une analyse de régression logistique multifactorielle. Deux complications ont servi à l'analyse. La complication 1 comprenait l'infarctus du myocarde (IM)/l'ischémie, l'angine, l'insuffisance cardiaque congestive, l'arythmie ou la mort. La complication 2 étendait la définition pour inclure, dans les complications cardiaques, «l'annulation de l'opération à cause des risques cardiaques».

Résultats : Le diabète, l'angine des classes III et IV de la Société Cardiovasculaire Canadienne (SCC) et l'IM se produisant pendant les six mois qui précèdent l'opération ont été étroitement associés aux deux complications cardiaques. Dans le cas des complications 1 et 2, les facteurs prédictifs médicaux et les risques chirurgicaux, considérés simultanément, ont montré une sensibilité de 93 % et une spécificité de 46-51 %. Considérés séparément, les facteurs prédictifs médicaux cliniques les plus importants ont présenté une sensibilité de 87-89 % tandis que les risques chirurgicaux ont montré une spécificité de 89 % en prédisant les deux complications.

Conclusion : Les facteurs prédictifs médicaux de la classification ACC-AHA ont été très sensibles alors que les risques chirurgicaux ont été plus spécifiques en prédisant des complications cardiaques postopératoires. Une étude prospective demeure nécessaire pour confirmer ces observations.

From the Departments of Anaesthesia,* Surgery,† Community Health and Epidemiology,‡ and Medicine (Division of Cardiology),§ Queens University, 76 Stuart St., K7L 2V7 Canada.

Address correspondence to: Dr. M.J. Ali, Department of Anesthesia, The Toronto Hospital, 200 Elizabeth Street, Toronto, Ontario, M5G 2C4 Canada. Phone: 416-340-3242; Fax: 416-340-3698; E-mail: mja@post.queensu.ca

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CARDIAC events account for more than half of the deaths after surgery in the United States,[1] and are associated with substantial treatment costs.[2] Population projections suggest that persons older than 65 yr, who are at high risk for cardiac events, will increase from 25% to 35% during the next 30 yr.[3] Members of this older demographic group experience high rates of cardiovascular disease, as well as the majority of surgical procedures performed in hospital settings.[5]

Recently, the American College of Cardiology - American Heart Association (ACC-AHA) published guidelines and an associated algorithm for the preoperative cardiovascular evaluation of non-cardiac surgical patients.[6] The purpose of these tools is to rationalize testing and to prevent unnecessary interventions in surgical patients. The ability of the guidelines to predict adverse cardiac events has not been tested empirically within a variety of surgical patient populations. Despite this, the ACC-AHA guidelines may become the standard approach used in clinical practice.

We had the opportunity to apply the ACC-AHA guidelines to a cohort consisting of patients undergoing non-cardiac surgery, who were referred to cardiology and/or anesthesia departments for assessment prior to surgery. The cohort was studied with the following objectives: 1) to describe the pre-operative clinical profile of these patients; 2) to determine what proportion of patients were treated in a manner consistent with the ACC-AHA guidelines; 3) to assess quantitatively the risks for negative seven day, postoperative cardiac events associated with the different classes of patients indicated by the guidelines, while simultaneously controlling for other factors; 4) to determine which aspect of the guidelines, clinical (medical) predictor or surgical risk scores, was a better predictor of seven day cardiac outcomes.

Methods

Study population

The study was conducted at two teaching hospitals situated in Kingston, Ontario; the Kingston General (KGH) and Hotel Dieu Hospitals (HDH). These hospitals are major centres for community and referral medical practice, with full complements of medical and surgical specialties. They serve a population of approximately 130,000 area residents.

Medical records of all patients (n=119) referred to cardiology and/or anesthesia services for preoperative consultation for non-cardiac surgery were reviewed retrospectively for a 15 mo period ending March 31, 1998. Most of these patients required elective or urgent surgery for a variety of conditions. Urgent surgery commonly involved repair of hip fractures, extremity amputations, and progressive limb ischemia requiring revascularization. Elective surgery in adults encompassed all systems except organ transplants. Patients with acute, life-threatening surgical emergencies who went directly to the operating room without cardiology consultation were excluded. Three patients were admitted more than once for separate surgical procedures during the course of the study. These were considered as independent events for the purposes of this study.

Classification according to the ACC-AHA guidelines

Table I provides a list of both the clinical and surgical characteristics that were considered during the application of the guidelines. Assessment of these patient characteristics allowed their classification according to a medical predictor score and a surgical risk score. Each of these scores has three levels; low, intermediate, and high; indicating the patients' potential risk for adverse cardiac outcome following surgery. The guidelines also provide investigation and management pathways associated with the various levels of risk (Figure). All 119 patients were classified according to the two scores.

We deemed patients with CCS class 3 or 4 angina, or with myocardial infarction less than three months before assessment, as demonstrating unstable coronary syndromes and classified them in the high-risk clinical predictor group.[7,8] Our use of the guidelines did vary subtly from the rules implied by the ACC-AHA algorithm. The ACC-AHA guidelines classify patients with previous MI, "mild" angina, compensated congestive heart failure, and diabetes mellitus into an intermediate risk group. Classification according to the clinical risk score is somewhat unclear for situations where patients have two or more factors suggesting "intermediate risks". For this study, based on previous clinical models of cardiac risk factors[9,10] it was assumed that a Canadian Cardiovascular System (CCS) class 2 angina patient, who also has diabetes and previous heart failure, is at a higher risk for postoperative cardiac event and merits a higher score than a similar patient with class 2 angina alone. We, therefore, classified patients with two or more "intermediate" clinical predictors into the high-risk group. The sole exception to this modified rule was that CCS class 1 or 2 angina in combination with MI greater than six months was considered as one clinical predictor, not two.[7] Patients with previous revascularization (coronary bypass surgery or angioplasty) were classified according to their current symptoms and clinical state.

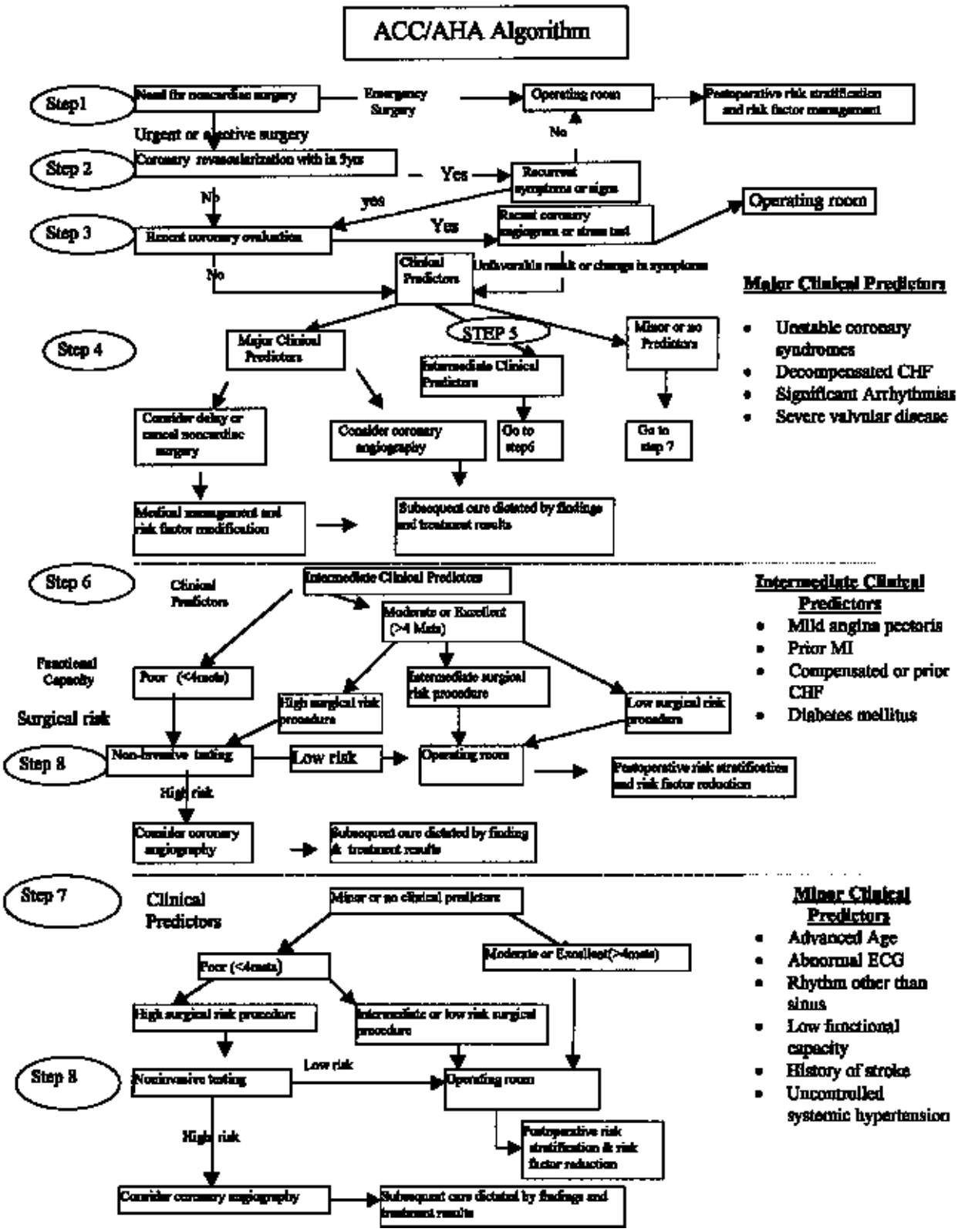

FIGURE Stepwise approach to preoperative cardiac assessment as per ACC/AHA Task Force Report[6] reproduced by permission

TABLE I ACC-AHA Guidelines for Management of Surgical Patients at Risk for Cardiac Event

Medical Predictor Score	*Surgical Risk Score*
High (Major) Risks: 1. MI 3 months prior to date of surgery 2. Angina (CCS classes 3 or 4) 3. Decompensated CHF 4. Significant arrhythmia with large fluid shifts 5. Severe valvular disease	High Risk Surgery: 1. Major emergency 2. Major vascular 3. Peripheral vascular 4. Anticipated prolonged surgical procedures associated
Intermediate Risks: 1. Angina (CCS classes 1 or 2) 2. Previous MI (> 3 months prior to surgery) 3. Prior or compensated congestive heart failure 4. Diabetes Mellitus	Immediate Risk Surgery: 1. Carotid endarterectomy 2. Head and neck 3. Intraperitoneal (abdominal) 4. Intrathoracic 5. Orthopedic 6. Prostate
Low Risks: 1. Age>70 2. Abnormal ECG 3. Rhythm other than sinus (e.g. atrial fibrillation) 4. History of CVA 5. Uncontrolled, systemic hypertension 6. Low functional capacity	Low Risk Surgery: 1. Endoscopic procedures 2. Superficial procedures 3. Cataract surgery 4. Breast surgery

TABLE II Description of the Patient Population Under Study

Characteristic	n	%
Total Patients	119	100
Sex:		
Male	54	45.4
Female	65	54.6
Surgical Procedures:		
Orthopedic	26	21.8
Hip Fracture	17	14.3
Joint Replacement and Other	17	14.3
Intraperitoneal	23	19.3
Vascular	16	13.5
Endoscopy	10	8.4
Superficial and Breast Surgery	8	6.7
Urology	6	5.0
Head and Neck54.2		
Intrathoracic	4	3.4
Carotid Endarterectomy	2	1.7
Opthalmology	2	1.7
Medical Risks:		
Previous MI		
< 6 months	13	10.9
6 + months	24	20.2
Angina:		
CCS 1 or 2	15	12.6
CCS 3 or 4	17	14.3
CHF	36	30.3
DM	19	16.0
Previous Revascularization	13	10.9
Inoperable Coronary	10	8.4
Valvular Disease	20	16.8
Severe Aortic Stenosis	5	4.2
Previous Valve Surgery	3	2.5

Consistency of patient management with the ACA-AHA guidelines

Through medical chart review, all patients in the study cohort were evaluated with respect to their medical management, and a determination was made to see if the latter was consistent with recommended investigative and therapeutic pathways[6] (Figure). Steps not followed in the ACA-AHA guidelines and their associated algorithm were documented.

Assessment of other patient characteristics

Data were also collected by medical chart review on previously established risk factors for cardiac events, which included patient demographics and co-morbid disease (diabetes, renal dysfunction, cerebrovascular, peripheral vascular, and chronic obstructive pulmonary disease).[7,10,13–18] The type of anesthesia employed during surgery, if applicable, was also recorded. These patients were followed clinically for seven days after surgery.

Seven - Day cardiac outcome

Negative, postoperative cardiac events were defined operationally as those that occurred during the seven days after surgery. They included diagnoses of at least one of: a) myocardial infarction (MI); b) ischemia; c) angina; d) congestive heart failure (CHF); e) arrhythmia; f) death. Cancellation of surgery due to perceived

TABLE III Bivariate Analysis. Factors associated with: 1) negative 7-day cardiac outcomes after surgery (Outcome 1), and, 2) negative 7-day cardiac outcome, including cancellation of surgery (Outcome 2)

Factor	*Negative Cardiac Outcome 1*			*Negative Cardiac Outcome 2 (Outcome 1 or cancellation of surgery)*		
	Yes (n=15)	*No (n=104)*	*OR (95% CI)*	*Yes (n=27)*	*No (n=92)*	*OR (95% CI)*
Age (yr):						
<70	3	43	1.0	9	37	1.0
70-79	7	37	2.7 (0.6, 14.4)	12	32	1.5 (0.5, 4.6)
80+	5	24	3.0 (0.6, 17.6)	6	23	1.1 (0.3, 3.9)
Sex:						
Male	6	48	1.0	11	43	1.0
Female	9	56	1.3 (0.4, 4.4)	16	49	1.3 (0.5, 3.3)
Diabetes:						
No	11	88	1.0	19	80	1.0
Yes	4	16	2.0 (0.5, 8.1)	8	12	2.8 (0.9, 8.8)
Angina prior to surgery:						
None	4	55	1.0	10	49	1.0
Class 1 or 2	6	36	2.3 (0.5, 10.6)	10	32	1.5 (0.5, 4.6)
Class 3 or 4	5	13	5.3 (1.0, 28.3)	7	11	3.1 (0.8, 11.7)
CHF before surgery:						
No	8	75	1.0	16	67	1.0
Yes	7	29	2.3 (0.7, 7.7)	11	25	1.8 (0.7, 4.9)
MI prior to surgery:						
No	5	64	1.0	8	61	1.0
Yes	10	40	3.2 (0.9, 11.7)	19	31	4.7 (1.7, 13.2)
Timing of MI before surgery:						
No MI	5	66	1.0	8	63	1.0
> 6 months	3	11	3.6 (0.6, 21.4)	12	22	4.3 (1.4, 13.5)
< 6 months	7	27	3.4 (0.9, 13.9)	7	7	7.9 (1.9, 34.7)
Type of Anesthesia						
General (GA)						
Regional/Local	10	63	1.0	10	63	1.0
(with or without GA)	5	29	1.1 (0.3, 3.9)	5	29	1.1 (0.3, 3.9)

cardiac risk was also documented. Criteria for diagnosis of the cardiac events remained with the consulting service, and we simply recorded their observations during our retrospective chart review. However, a cardiologist involved in the study, used serial electrocardiograms, rhythm strips, cardiac enzymes and chest X-rays to confirm these diagnoses. If patients were discharged from the hospital earlier than seven days after surgery, medical record data base of KGH and HDH were scanned to pick up subsequent admissions for cardiac or surgical reasons. This strategy would pick up cardiac events as KGH and HDH are the only major hospital for admission and treatment of acute cardiac problems in the catchment area.

Analysis

Characteristics of the study population were described using univariate statistics. The percentage of patients who were managed according to the ACC-AHA protocol was calculated. Associations between independent variables and negative cardiac outcomes were quantified using logistic regression and chi-square statistics. Two study outcomes were employed in separate analyses. The first defined a negative, seven-day cardiac outcome as any listed in a) through f) above. The second expanded the definition to include cancellation of surgery due to cardiac risk as a negative cardiac outcome. The sensitivity and specificity of the medical predictor and surgical risk scores in predicting negative cardiac outcomes were calculated. This was done for the two scores alone, and then in combination.

The approach to logistic regression modeling went as follows. First, bivariate analyses were used to assess the strength and statistical significance of associations between patient characteristics and the two negative cardiac outcomes. Second, similar analyses were used to describe associations between the 1) ACC-AHA medical predictor score, and 2) ACC-AHA surgical risk score, and the two measures of negative (or poor) cardiac outcomes. Third, multiple logistic regression

TABLE IV Multiple Logistic Regression Analysis: Associations Between ACC-AHA Risk Scores and negative 7-day cardiac outcomes (not including cancellation of surgery; Outcome 1)

ACC-AHA Score	*Negative Cardiac Outcome*		OR_{crude}	$OR_{adjusted}$ *	*Sensitivity†*	*Specificity‡*
	Yes (n=15)	*No (n=104)*	*(95% CI)*	*(95% CI)*		
Medical Predictor:						
Low or Intermediate	2	54	1.0	1.0	86.7	51.9
High	13	50	7.0 (1.5, 32.7)	5.1 (1.0, 26.1)		
Surgical Risks:						
Low or Intermediate	10	93	1.0	1.0	33.3	89.4
High	5	11	4.2 (1.2, 14.6)	3.7 (1.0,13.3)		
Medical and Surgical:						
Low or Intermediate	1	58	1.0	1.0	93.3	46.2
Either Score High	14	56	12.0 (1.5,73.8)	8.8 (1.1,73.8)		

* adjusted for risk factors identified in Table III (diabetes; timing of MI prior to surgery)

† ability of score to identify patients as "high risk", who had a negative, 7-day cardiac outcome

‡ ability of score to identify patients as "low or intermediate" risk, who did not have negative outcome

TABLE V Multiple Logistic Regression Analysis: Associations Between ACC-AHA Risk Scores and poor 7-day cardiac outcomes (including cancellation of surgery; Outcome 2)

ACC-AHA Score	*Negative Cardiac Outcome*		OR_{crude}	$OR_{adjusted}$ *	*Sensitivity†*	*Specificity‡*
	Yes (n=27)	*No (n=92)*	*(95% CI)*	*(95% CI)*		
Medical Predictor:						
Low or Intermediate	3	53	1.0	1.0	88.9	57.6
High	24	39	10.9 (3.1, 38.7)	6.5 (1.7, 25.0)		
Surgical Risks:						
Low or Intermediate	21	82	1.0	1.0	22.2	89.1
High	6	10	2.3 (0.8, 7.2)	2.0 (0.6, 6.7)		
Medical and Surgical:						
Low or Intermediate	2	47	1.0	1.0	92.6	51.1
Either Score High	25	45	13.1 (2.9, 58.4)	7.9 (1.7, 37.2)		

* adjusted for risk factors identified in Table III (diabetes; timing of MI prior to surgery)

† ability of score to identify patients as "high risk", who had a negative, 7-day cardiac outcome

‡ ability of score to identify patients as "low or intermediate" risk, who did not have a negative outcome

analyses were used to quantify these associations, while simultaneously controlling for other risk factors identified in bivariate analysis.

Results

Study population

The patient population under study is described in Table II according to the types of surgery that they were being assessed for, and medical risks documented at the time of surgery. The mean age of the 119 patients was 71.2 ± 11.9 yr.

Application of the ACC-AHA guidelines

Patients were classified by predicted risks for surgery according to the medical predictor and surgical risk scores found in the ACC-AHA guidelines (Table I). The medical predictor scores indicated that 18 patients had minor predictors and were at low risk for surgery, 38 had intermediate risks, and 63 had high risks. Fifteen patients had more than two intermediate medical predictors and were included in the group of 63 patients with high risks. In contrast, the surgical risk score indicated 18 as low risk procedures, 85 as intermediate procedures and 16 as high risk procedures.

With respect to the medical predictor score, 18 patients classified as "low" risk and 38 as "intermediate" risk were managed based on their activity levels, as suggested by their medical history[11,12] and type of surgery[4] (Table I). Patients with an acceptable level of activity, defined as being able to climb a flight of stairs or walk up a hill (4 metabolic equivalent/met by Duke activity status[11,12]), slated for intermediate or low risk

procedure went directly to surgery, while those with limited ability to exercise underwent further cardiac testing and treatment if dictated by the ACC algorithm[6] (Figure). Among patients with a high medical predictor risk score, anesthesia and surgery was delayed in 50 and canceled or modified in 13 patients. Urgent surgery (e.g. hip fracture) was performed after limited investigation and medical optimization of acute conditions such as rhythm disturbance and congestive heart failure, as appropriate. The remaining high-risk patients underwent cardiac testing and treatment.

Ninety-six percent (n=114) of the patients were treated according to the ACC-AHA guidelines, upon retrospective application of the medical predictor score and algorithm.[6] In the five cases where the guidelines were not followed, clinicians failed to document the patients' exercise tolerance. No adverse events were observed among these patients. Where indicated, cardiac testing included 2D echocardiogram in 32 patients, coronary angiogram in eight, 24 hr Holter monitoring in six, exercise stress test in four and stress echo in three. Cardiac treatment included introduction or change in cardiac medication including nitrates, calcium antagonists, diuretics or antiarrhythmics. Widespread use of ß blocker was absent despite recent support for their use.[19,20]

Bivariate analysis

Associations between a variety of patient characteristics and negative seven-day cardiac outcomes are quantified in Table III. In general, the strength and direction of associations were consistent for the two negative cardiac outcomes employed. Strong associations that approached statistical significance ($P < 0.10$) were observed for the presence of diabetes, CCS Class III or IV angina, MI prior to surgery, and MI within six months of the scheduled date of surgery.

Table IV shows the risks for the first negative, seven-day cardiac outcome associated with ACC-AHA medical predictor and surgical risk scores. There were 15 adverse cardiac events; four MI, six CHF, two ischemic ST-T changes, two arrhythmias, and one from low cardiac output state from ongoing surgical bleeding. Four of the events were fatal, two from MI, one from CHF and one from bleeding and low cardiac output state. The "high risk" medical predictor score identified 13 of 15 (86.7%) patients who had a negative, seven-day cardiac outcome, while the "high" surgical risk score identified five of these 15 patients (33.3%). In contrast, the surgical risk score had a high (89.4%) specificity relative to the medical predictor score (51.9%). When results from the medical predictor and surgical risk scores were considered simultaneously, sensitivity (93.3%) improved at the expense of specificity (46.2%).

When cancellation of surgery was included as a negative cardiac outcome (Table V), the results remained similar. The medical predictor score identified 24 of 27 patients (sensitivity 88.9%) with negative cardiac outcomes, compared with six of 27 patients (sensitivity 22.2%) for the surgical risk scores. The specificity associated with the surgical risk score remained high (89.1%) relative to medical predictor score (57.6%). A marginal increase in sensitivity was observed along with a lower specificity when the two scores were considered simultaneously. In short, the medical predictor score was highly sensitive in detecting patients at high risk for negative cardiac outcome, while the surgical risk score was less sensitive and more specific.

Multiple logistic regression analysis

Risks for a negative cardiac outcome (both types) were strongly associated with a "high" medical predictor score, and more modestly associated with a "high" surgical risk score. This is reflected in the crude odds ratios presented in Tables IV-V, as well as the results of the multiple logistic regression analysis, where odds ratios are simultaneously adjusted for the influence of important covariates identified in the bivariate analysis.

Discussion

Since their introduction, the ACC-AHA guidelines have been used widely for perioperative cardiac risk assessment and therapeutic modification.[21,23] They are intended to optimize the chance for a satisfactory cardiac outcome following non-cardiac, surgical procedures. However, unlike previous risk indices,[7,16,22,24–26] the ACC-AHA guidelines have not been validated within cohorts of surgical patients in various settings. This is required in order to determine whether the guidelines are useful in consistently identifying patients at high risk for negative cardiac outcomes.

Our results were consistent with previous studies, in that recent MI, diabetes, advanced angina, and CHF were all shown to be predictors of a negative outcome following non-cardiac surgery.[7,9,13] In addition, we showed that the medical predictor score in the ACC-AHA classification scheme performed extremely well, with a sensitivity of 87% in predicting adverse cardiac events, in a diverse group of surgical patients. The medical predictor score performed much better then the surgical risk score in identifying high-risk patients. This suggests that cardiac conditions that patients bring to the operating room are a more important determinant of adverse outcome than the type of surgery they are about to undergo.

Limitations to the ACC-AHA guidelines and our study must be stressed. For example, the ACC treatment algorithm is broad and permits more than one management pathway in certain circumstances. A patient presenting with stable CCS class 2 - 3 angina, for example, can be correctly managed with coronary angiography and revascularization (coronary angioplasty or coronary surgery), or be optimized with cardiac medication prior to non-cardiac surgery.[27,28] This allowed clinicians with different management strategies to remain in compliance with the guidelines and algorithm. Objective outcome comparison of conservative *vs* invasive approach with in the ACC guidelines was not possible in this study as only a few patients underwent revascularization.

Second, the guidelines are not clear on how long to delay surgery after introducing cardiac medication to optimize patient's preoperative cardiac condition. In addition, they do not indicate how to assess perioperative risk reduction benefit once a drug is started. In our setting, these medications were often started the evening prior to surgery.

Third, a large portion of the guidelines is based on observational or retrospective studies, as well as knowledge of cardiovascular disease management in non-operative settings.[6] Similarly, this study was a retrospective evaluation of 119 surgical patients selected on the basis of being referred for a cardiology and anesthesia consultation. Therefore, caution must be used in extrapolating the estimate of the cardiac events from this retrospective cohort to an unselected surgical population since the prevalence and outcome may vary as shown recently in another condition.[29] The guidelines have yet to be clinically evaluated prospectively in a large population, and in operative settings.

We used traditional cardiac outcomes such as angina, congestive heart failure, arrhythmia, myocardial infarction and ischemic ST-T changes. In addition, we felt that cancellation of surgery for cardiac reasons deprived patients of the potential for cure of their surgical disease, and therefore considered it as a novel but clinically relevant negative outcome variable. For example, one patient in our study was denied curative lobectomy[30] for carcinoma of the lung due to cardiac risk of surgery. However, the results of the analysis were consistent with those obtained when surgery cancellation was not considered as a negative study outcome.

Alternative techniques to treat diseases traditionally requiring stressful surgery may offer attractive options to reduce cardiac risk in future.[31] This was possible in only three patients in our study. Two underwent percutaneous cholecystostomy and endoscopic gallstone removal while one under went bronchial embolization instead of thoracotomy. There were no adverse cardiac events in these patients.

Some authors have suggested that non-cardiac morbid events such as respiratory complications, renal failure, strokes, and bleeding requiring major transfusion exceed perioperative cardiac events.[32–34] We did not observe that to be true. In our study, only one patient succumbed to postoperative surgical bleeding and low cardiac output state. However, we did not specifically document postoperative serum creatinine, chest x-ray findings or arterial blood gases in this study.

Anesthetic technique was not a determinant of cardiac outcome in this study. Again, this is consistent with earlier findings.[35,36] The effect of postoperative analgesic regimen on cardiac outcome was not investigated in this study.

This study included a diverse group of patients likely to be seen in a busy surgical, anesthetic and cardiology practice. The patient mix involved a variety of ischemic, valvular, arrhythmic and other cardiac conditions encountered frequently in the operating room. We believe this validation study to be unique in that evaluation of the ACC-AHA guidelines in a cohort such as this has not been reported.

The study confirms that the ACC-AHA guidelines and risk classification of surgical patients were predictive of postoperative adverse cardiac events. It suggests that the clinical (medical) predictor score was highly sensitive in detecting patients at high risk for negative cardiac outcome, while the surgical risk score was less sensitive and more specific. Prospective study with a larger group of surgical patients recruited from a preoperative assessment clinic is warranted to confirm these observations.

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